

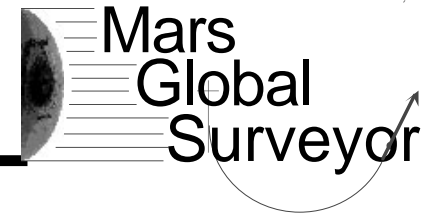


MGS Mass Properties

5/15/96

Jim Taylor

May 8-9 Spin Test for Mass Properties



1. **Weigh Spacecraft**
Minimum Non-Flight Hardware (Configured for Acoustics)
IPA Loaded (95% all Tanks)
Develop “Puts and Takes” List
2. **Measure Center of Gravity**
Three Locations Achieved With Ballast
3. **Measure Products of Inertia**
Two Measurements with Different Center of Gravity
4. **Measure Z-Axis Moment of Inertia**
5. **Conduct Spacecraft Magnetism Survey**
6. **Measure Spacecraft Launch Envelope**

Spacecraft Mass (5/15/96)



MGS Spacecraft Weight Analysis				
Latest Measurement May 9, 1996	CBE	CBE+Growth	CBE - ΔV (20.7mps)	CBE + Growth - ΔV (20.7mps)
Installed Items (MEL)	587.08	587.59	587.08	587.59
Correction to MEL	0.67	0.67	0.67	0.67
Flight Items to Be Added (Estimated)	38.39	42.98	38.39	42.98
Flight Items to Be Added (Weighed)	43.45	43.97	43.45	43.97
Total S/C CBE Dry Mass, kg	668.92	674.54	668.92	674.54
Total S/C CBE Wet Mass, kg	1053.76	1062.60	1044.68	1053.44
Fuel,kg	233.57	235.53	227.20	229.11
Fuel Margin, KG	1.27	-0.69	7.65	5.74
Fuel Margin, % (Negative Means Over Fill)	0.54%	-0.29%	3.37%	2.51%
Oxidizer, kg	151.26	152.53	148.55	149.80
Oxidizer Margin, kg	16.96	15.69	19.67	18.43
Oxidizer Margin, % (Negative Means Over Fill)	11.22%	10.29%	13.24%	12.30%
Total Propellant Loaded	384.83	388.06	375.75	378.90
Total Growth Mass		5.10		5.10
Growth Mass Installed Items		0.51		0.51
Growth Mass NOT Installed Items		4.59		4.59

ΔV 's and Burn Times (Budget)



MEA ISP, sec =	317.00			Wet Mass, kg	1 053.76
MEA, Blowdown Isp=	315.00				
ACS ISP, sec =	220.00				
ACS, pulse Isp=	190.00				
Engine Mass Flow, kg/sec	0.21				
Maneuver	ΔV ,m/sec Monoprop	ΔV ,m/sec Biprop	Post Burn S/C Mass,kg	Burn Time,sec ACS	Burn Time,sec Main Engine
TCM 1,2	0.30	49.90	1036.82	18.33	79.69
TCM 3,4	3.00	0.00	1035.38	180.09	0.00
MOI	5.90	975.60	753.67	353.45	1323.61
Aerobraking Walk-in	2.60	8.00	750.81	113.46	9.25
Aerobraking Main Phase	5.00	0.00	749.07	217.25	0.00
Aerobrake Main Phase	5.00	0.00	747.07	250.93	0.00
Aero Walk-out:t:Trans	20.00	0.00	740.17	861.68	0.00
Aero Walk-out: Rot	30.00	0.00	728.35	1477.74	0.00
TransMap-ABX	0.40	60.20	714.25	16.88	66.30
TransMap-TMO	0.10	16.10	710.52	4.14	17.51
Aerobrake Pop-Up	2.50	14.50	706.37	102.86	15.79
V Reserves	2.00	10.70	703.28	81.81	11.59
Mapping-OTM	3.90	7.50	700.30	158.77	8.09
Mapping-ACS	40.00	0.00	685.43	1859.21	0.00
Quarantine Orbit	12.00	0.00	681.63	475.23	0.00
Relay-OTM	4.80	0.00	680.11	189.35	0.00
Relay-ACS	10.00	0.00	676.47	455.04	0.00
TOTALS	147.50	1142.50		6816.21	1531.84
TOTAL V, m/sec	1290.00				
TOTAL PROP, kg:	384.83				
ALLOW. DRY MASS, kg	668.92				

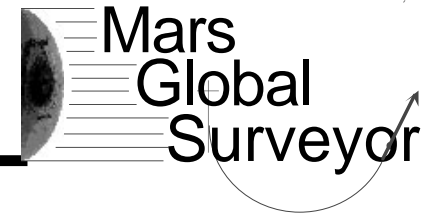
Maneuver	ΔV ,m/sec Monoprop	ΔV ,m/sec Biprop
TCM 1,2	0.30	42.00
TCM 3,4	3.00	0.00
MOI	5.90	975.60
Aerobraking Walk-in	2.60	8.00
Aerobraking Main Phase	5.00	0.00
Aerobrake Main Phase	5.00	0.00
Aero Walk-out:t:Trans	20.00	0.00
Aero Walk-out: Rot	30.00	0.00
TransMap-ABX	0.40	60.20
TransMap-TMO	0.10	16.10
Aerobrake Pop-Up	2.50	14.50
V Reserves	2.00	5.60
Mapping-OTM	3.90	7.50
Mapping-ACS	40.00	0.00
Quarantine Orbit	17.00	0.00
Relay-OTM	0.70	0.00
Relay-ACS	1.40	0.00
TOTALS	139.80	1129.50
TOTAL V, m/sec	1269.30	

Spacecraft Mass Growth Allowances



Item	Percent Growth
Ballast	100.00%
MLI	20.00%
Radome	10.00%
NSI's	10.00%
Coatings, Paint, Teflon	10.00%
MLI Ground Straps	5.00%
Connector Covers	5.00%
Flight Batteries	1.00%
Main Enable Plug	1.00%
MOLA	1.00%
TES	1.00%
Installed and Weighed Equipment	0.10%

Accuracy Of Measurements



Load Cell $\pm 0.25\%$ of Lift-Tare = ± 2.39 kg

IPA Loaded Fuel = $\pm .45$ kg

= ± 2.4 kg

IPA Loaded Oxidizer = $\pm .23$ kg

**Remove Before Flight (weighed Items 1%
and estimated Items 10%)**

= ± 1.8 kg

Remove Before Flight Items (5/15/96)



Item	Mass (Kg) Weighed	Mass (Kg) Estimated	Comments
Total of All Items	359.87	9.19	369.06
			NOTE: Bubble Wrap 5.91 Grams/Ft ² ; Plastic Wrap = 5.68 grams/Ft ² ; Pink Poly = 6.72 grams/Ft ² ; Kapton Tape= 1.56 Grams/Ft.; Purge Line = XXX Grams/Ft., Red Tag = 9 grams each
Equipment Module	0.05	0.16	
<u>-X Panel</u>			
2 SSD Covers	0.05		Weighed 2/26 (26.7 grams each including screws)
150 inches of tape		0.02	
2 Red Tags		0.02	
2 Plastic Coverings over radiators		0.02	Est 3 sq ft
<u>-Y Panel</u>			
40 inches tape		0.01	
<u>+X Panel</u>			
110 inches Tape		0.01	
2 Red Tags		0.02	
6 Purple Connectors for Burn Wires		0.06	Est at 10 grams @
<u>+Y Panel</u>			
50 inches of Tape		0.01	

Remove Before Flight Items (5/15/96)



Propulsion Module	0.05	0.15	
<u>-X Side</u>			
Plastic on He Tank		0.02	Est 3 sq ft
2 Red Tags		0.02	
<u>-Y Side</u>			
Dust Cover		0.01	On Electrical Tower Below Deck
2 Red Tags		0.02	
2 MAG Hazard Labels		0.01	
<u>+X Side</u>			
2 SSD Covers	0.05		weighed 2/26
70 inches Tape		0.01	
<u>+Y Side</u>			
Dust Cover		0.01	On Electrical Tower Below Deck
100 inches Tape		0.01	
4 Red Tags		0.04	
2 Non Conformance Stickers		0.00	

Remove Before Flight Items (5/15/96)



Nadir Equipment Deck	46.32	0.37	
MOC Soft Cover		0.10	Weighed 4/18
ER Cover	0.11		Weighed at Vendor
CSA Cover	0.16		Weighed 5/14/96 at 5.63 Oz
4 MHSA Lens Covers	0.28		70 grams each
2 SSD Covers	0.05		26.7 gram each
MR 50 OHM Load Resistor (J5)		0.05	Greg H. Estimate
2 MR Connector Savers		0.01	Greg H. Estimate (10 grams @)
MOLA Mass Simulator	26.99		This is flight weight
25 feet of purge line		0.20	
MOLA Lifting Lugs	0.46		Weighed 5/14/96 at 16.07 Oz.
TES Mass Simulator	14.70		
Kapton Tape (100 inches)		0.01	
S/C Lifting Lugs	3.57		

Remove Before Flight Items (5/15/96)



High Gain Antenna	0.00	0.00	
Solar Arrays	0.11	0.00	
4 SSD Covers	0.11		2 on each panel 26.7 gram each
Other Equipment	313.47	8.52	
28 NSI Simulators	0.33		
Thruster Nozzle Caps and Foam	0.03		2.5 grams each
2 Battery High Side Enable Tool <u>Was NOT Installed</u>			Weighed by Zercher (956 grams each)
2 Test Batteries	26.53		Weighed
Fuel Tanks Referee Fluid (IPA)	181.22		Estimated Loading Accuracy \pm 1 pound
Ox Tank Referee Fluid (IPA)	90.50		Estimated Loading Accuracy \pm 0.5 pound
NED Witness Plate	0.80		
Ballast	3.64		
1 Ballast Bracket Thermal	0.03		
Clip & Screws	7.37		
Accels Wires (41)	1.74		
Blocks for Accel Mount (37)	1.29		
Accels (41-302's & 6-306's))		8.52	
Thermocouples, Wire, Connectors (261 +66)			

Install Before Flight Items (5/15/96)



Item	Mass (Kg)	Comments	
Total of All Items	81.85	Estimated=	38.39
		Weighed=	43.45
Equipment Module	1.46	Comments	
*6 MLI Blankets & Straps	1.46	Est.	
Propulsion Module	34.35		
*38 MLI Blankets & Straps	3.93	Est.	
4 Ballast Bracket Thermal Clips & Screws	0.12	30.8 gs @	
28 NSIs	0.33		
Flight Batteries	26.53	Est.	
Ballast	2.00	Est. Nominal Value	
Pressurant (He)	1.43		
Nadir Equipment Deck	43.48		
MOLA (w/Attach H/W)	26.99		
TES	14.70		
MR J6 D/A Connector Cover	0.01		
MAG J6 D/A Connector Cover	0.01		
ER High Voltage Enable Plug	0.01		
*17 MLI Blankets & Straps	1.76	Est.	

High Gain Antenna	1.54
*26 MLI Blankets & Straps	1.43
HGA Radome	0.11
Solar Arrays	0.75
*26 MLI Blankets & Straps	0.75
Thermal (Other)	0.27
20 closeout blankets	0.27

Spin Test Results (5/9/96)



Measured Values		Spacecraft Values	
Xcg	Ycg	Xcg	Ycg
0.0690	-0.1415		
Ixz	Iyz	Ixz	Iyz
Izz	Principal Axis	Izz	Principal Axis
Add Ballast			
+X,+Y	-X,+Y	-X,-Y	+X,-Y
	1.94 kg		
Measured Values		Spacecraft Values	
Xcg	Ycg	Xcg	Ycg
0.0024	-0.0673		
Ixz	Iyz	Ixz	Iyz
-15241	-3367		
Izz	Principal Axis	Izz	Principal Axis
Add Ballast			
+X,+Y	-X,+Y	-X,-Y	+X,-Y
	3.635 kg		
Measured Values		Spacecraft Values	
Xcg	Ycg	Xcg	Ycg
-0.0533	-0.0016		
Ixz	Iyz	Ixz	Iyz
-16825	-490		
Izz	Principal Axis	Izz	Principal Axis
1302011			

Ballast Requirements

C.G. \leq .13 cm
Principal Axis \leq 1 deg.

	+X,+Y	-X,+Y	-X,-Y	+X,-Y
TOP				
BOT				





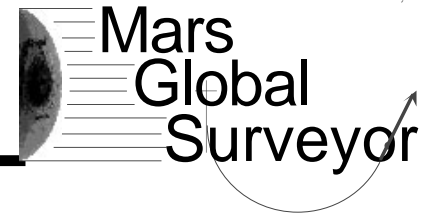
Preliminary Launch Envelope Verification

- HGA and Solar Arrays Will Be Deployed During ATLO Testing
 - Solar Arrays Will Be Removed For Shipping to KSC
 - Thermal Blankets Not Installed
 - Repeatability of Installation Expected to Be Very Good (± 0.010 inch)
 - Spacecraft Rotation Facilitated By Spin Table Air Bearing Rotated (Manual) To Proper Positions - Then Locked Down For Measurements
- No Immediate Issues. MDAC Reviewing the Numbers

Measurement Point	Mission Specification	Measure	Difference
HGA Strut	50.900	50.920	0.020
HGA Strut	51.200	51.250	0.050
HGA Dish Edge	51.100	51.150	0.050
Solar Array +X,+Y	49.20	49.240	0.040
Solar Array +X,-Y (RTV)	49.20	49.560	0.360
Solar Array -X,-Y (Wir	49.20	49.330	0.130
Solar Array -X,+Y (Wir	49.20	49.560	0.360
Ballast (-X,+Y)	49.80	49.580	-0.220

Nominal Envelope Radius=50 inches





Spacecraft Magnetics Survey

Two Magnetometers Located at Solar Array Gimbal Elevation at Distances Of 3 feet and 5 feet from solar array

Spacecraft Rotated Approximately 5 RPM for 10 (+) Revs CW and 10 (+) Revs CCW

Technique gave an excellent magnetic signature of the spacecraft.

Results show a dipole that is slightly out of spec. Most likely source is the TWTA assembly.

MAG PI is continuing to analyze the data to determine if corrective action is required.

Things To Do



1. Update Spacecraft Mass Properties Math Model
2. Determine Spacecraft Ballast Requirements (Preliminary)
3. Determine MOI's for Mapping Orbit to Get Momentum Unload ΔV Update
4. Next Spin Test After Thermal Vac (July 23)
5. Last Spin Test at KSC
 - Spin Table Setup
 - Wet or Dry?
 - KSC Safety Requirements

Launch Safe Mode & DSN Acquisition Time Available



A Discovery (During ATLO Testing) - Safe Mode Monitors Bus Current - Instead Of the Intended Total of Solar Array Current and Bus Load.

Safe Mode Turns Off The TWTA For 2 Hours (Then On For 2 Hours) If Insufficient Current. Helps Prevent Damage to The Batteries If No Sun on The Arrays.

- Designed for Eclipse Detection**
- Also Works Great for Aerobrake**
- Also Works (Needed) If Solar Arrays Did Not Deploy Properly**

Launch Safe Mode & DSN Acquisition Time Available



The Problem:

During Launch The Bus Current From The Box Loads Plus The Solar Array Charge Current Is Sufficient For Safe Mode To Leave The TWTA ON.

However, The Batteries Will Be Re-Charged in About 1 Hour And the 7.5 Amps Charge Current Goes to Zero. The Remaining Current Is Not Sufficient For The Safe Mode Monitor to Leave The TWTA Turned On.

Launch Safe Mode & DSN Acquisition Time Available



Solutions:

- 1. Install a Software Patch To Turn the TWTA On if Safe Mode Entered During Launch - and Leave it On.**
 - a) Works Only If Memory Not Scrambled**
 - b) Memory Lost If Safe Mode Entered Do to POR**

- 2. Install Hardware Fix to Make Safe Mode Monitor the Solar Array Current (Including the Current Dumped to the PSA's)**
 - a) Hardware is Being Designed and Will Be Ready for Installation - When an Opportunity Arises.**
 - b) Requires Opening the EM - And NOBODY Wants to Do That Because of Completed ATLO Testing.**

- 3. Prepare Emergency Ground Command To Turn TWTA On**
 - a) Need Initial Acquisition To Know That It Is OK To Turn TWTA On (Do We Really Have Power on The Arrays?)**